

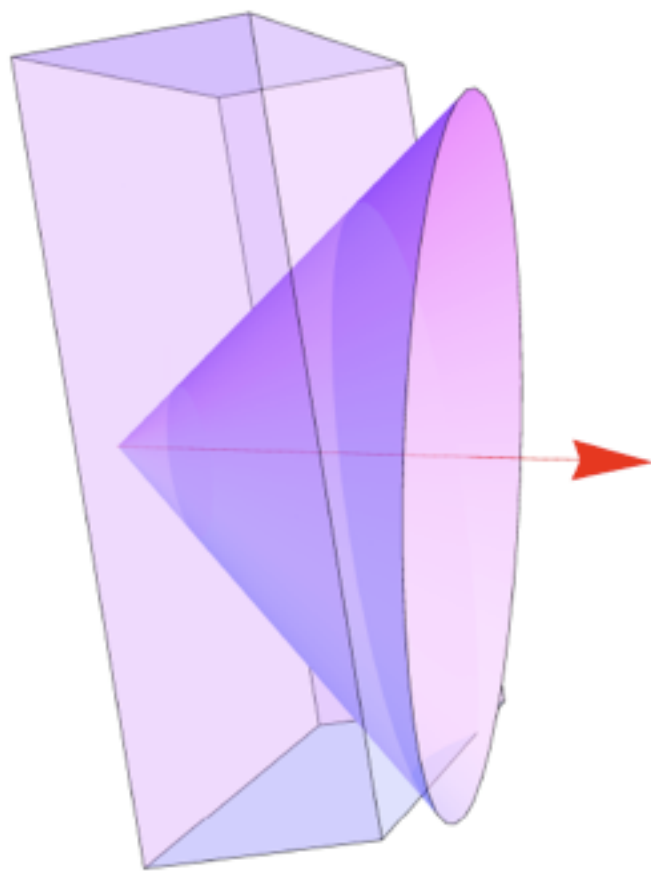
calibration using a small Low energy accelerator

S. White, BNL LBNE meeting
2/5/10

- Michel electrons correspond to the energy of electron machines used in other fields
- these can be ordered through eg. Radia Beam, AES
- or adapted from several machines now being excessed- eg. MIT, Vanderbilt FEL
- construction and ops. cost is significant
- these machines have interesting parameters- ie 3 psec time structure of ATF
- hard to operate them below $\sim 10^7$ to 10^8 electrons/pulse

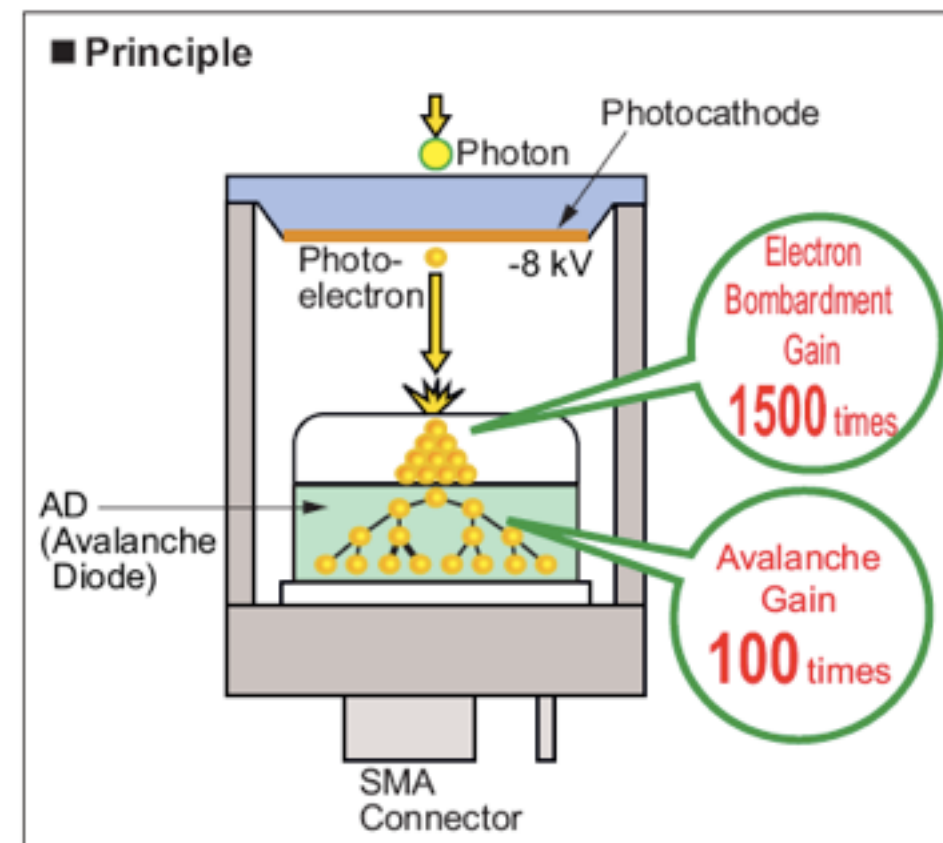
We are developing a scattered beam of 1 electron/pulse

This could be useful for LBNE energy calibration



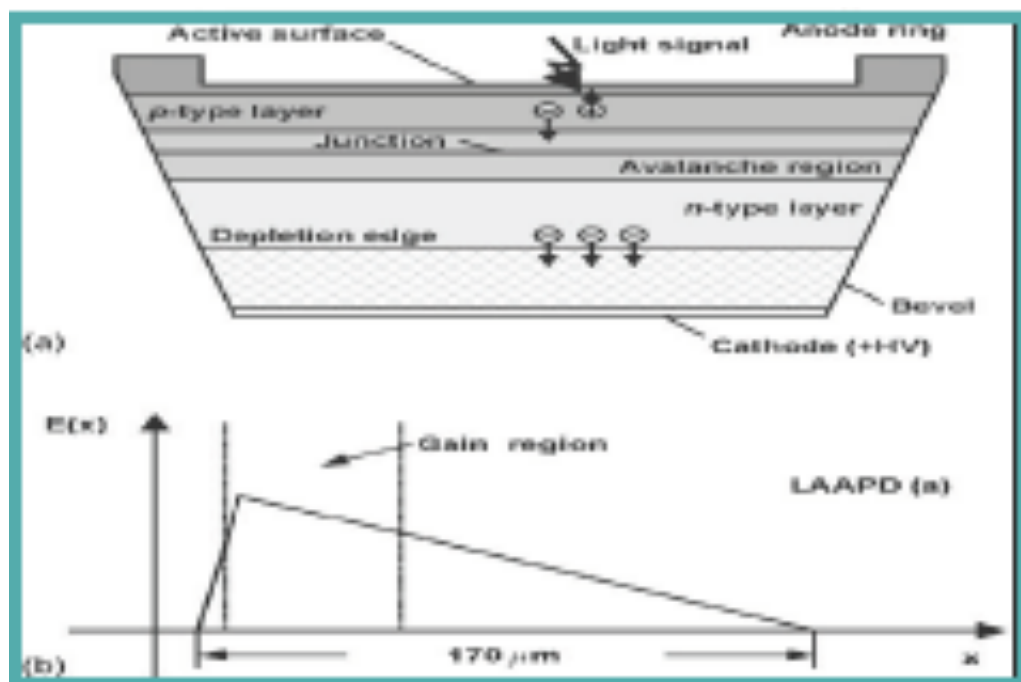
Cerenkov Radiation cone

Cerenkov
or
APD
option

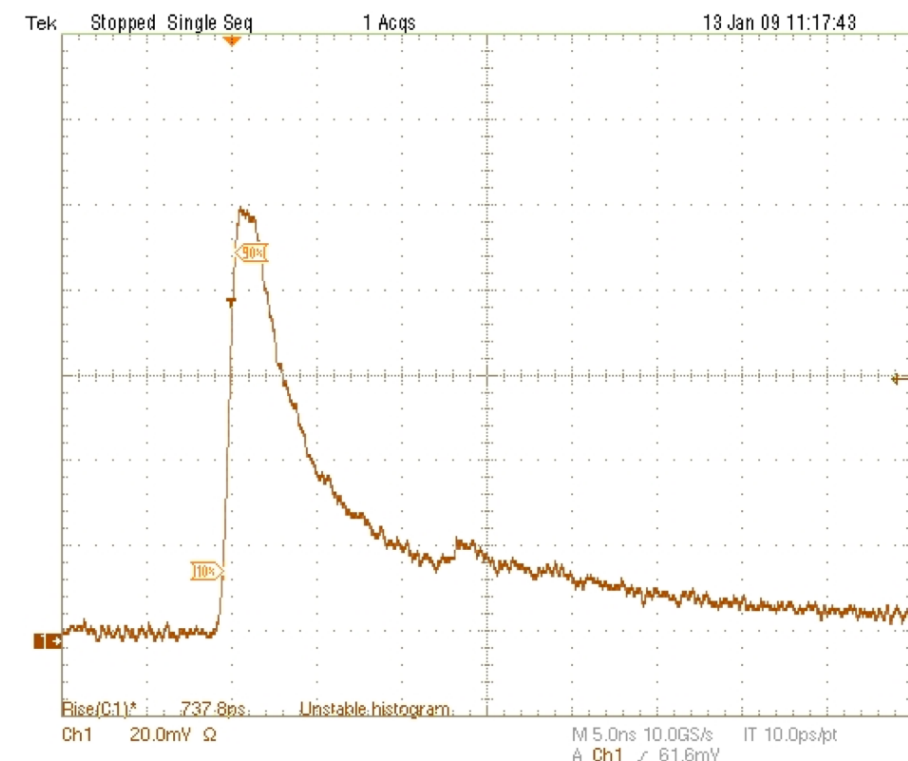


Pre-production Hybrid photodetector

“A 10 picosecond time of flight detector using APD’s”, SNW et al.



Deep diffused avalanche photodiode

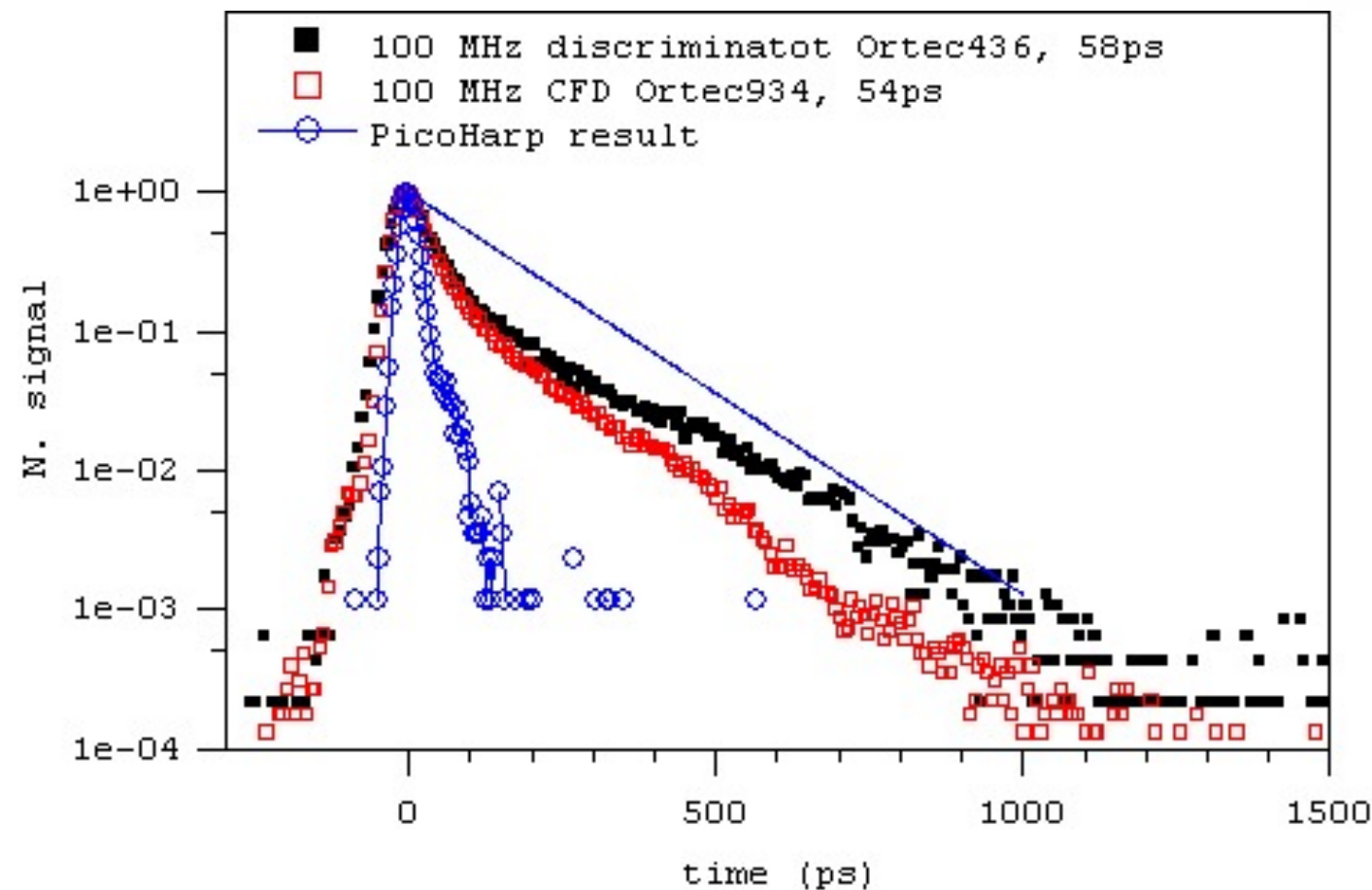
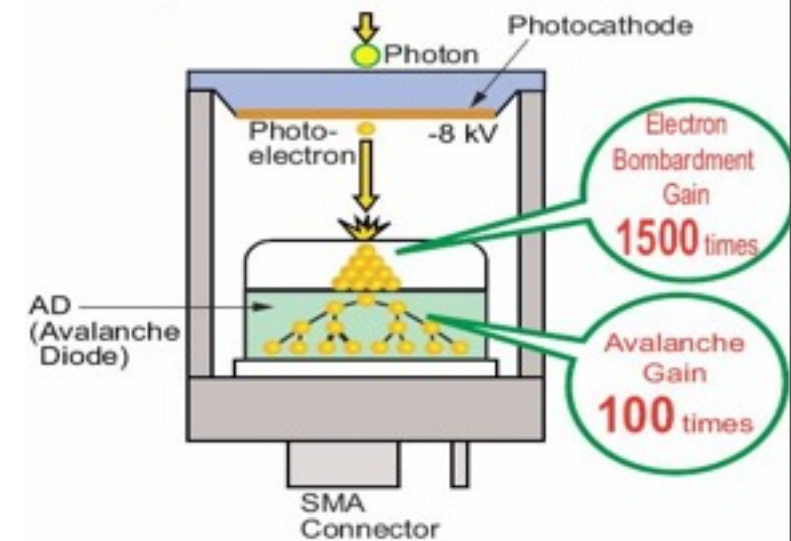
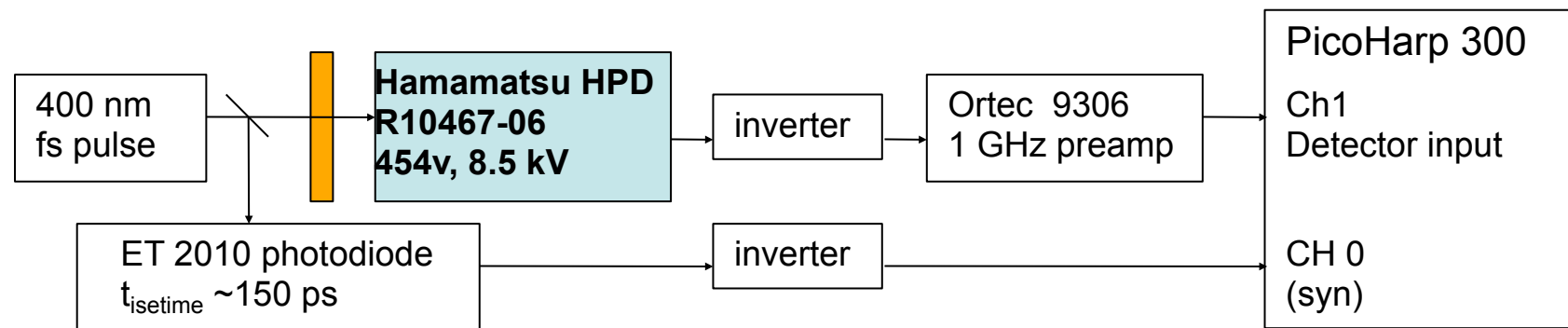


650 picosecond risetime (β's)

Sebastian White

02/04/10

Transit time spread & time jitter, using 100 MHz leading-edge vs CFD vs PicoHarp (good results from laser measurements at BNL. Now preparing e⁻ beam run.)



PicoHarp TTS measurement = $\sqrt{(32 \text{ ps})^2 - (18 \text{ ps})^2} = \sim 26.4 \text{ ps (FWHM)}$
A short exponential tail remains.

-> going into beam test rms jitter from electronics & TTS < 10^{-11} sec

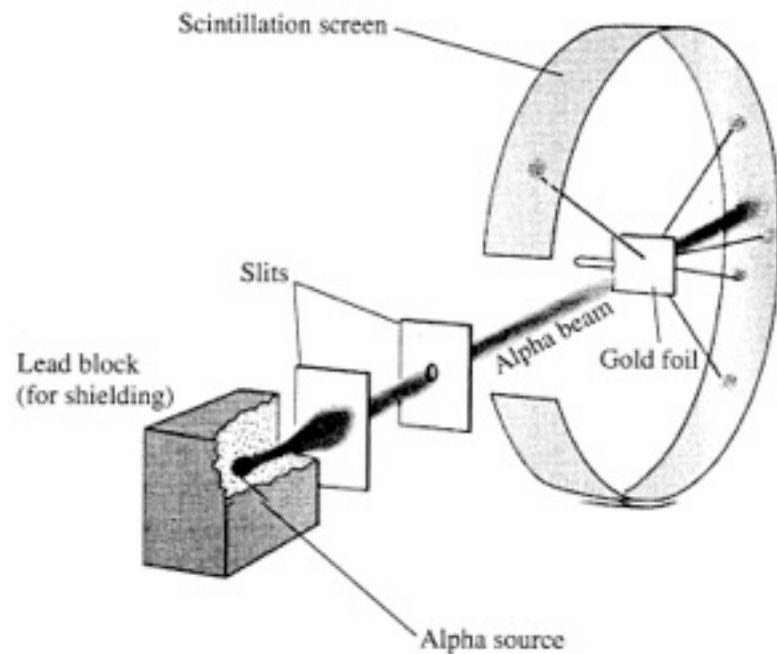
Elastic Scattering and Atomic Structure

- Rutherford, Geiger, Marsden (1909)
 - Atom's 100th Birthday!
 - Rutherford's teacher, JJ Thomson, discovered electron 10 years earlier
- “counter experiment”
 - Beam of 5 MegaVolt α particles from Radium C decay
- R. showed that α = Helium Nucleus

JJ Thomson & Ernest Rutherford



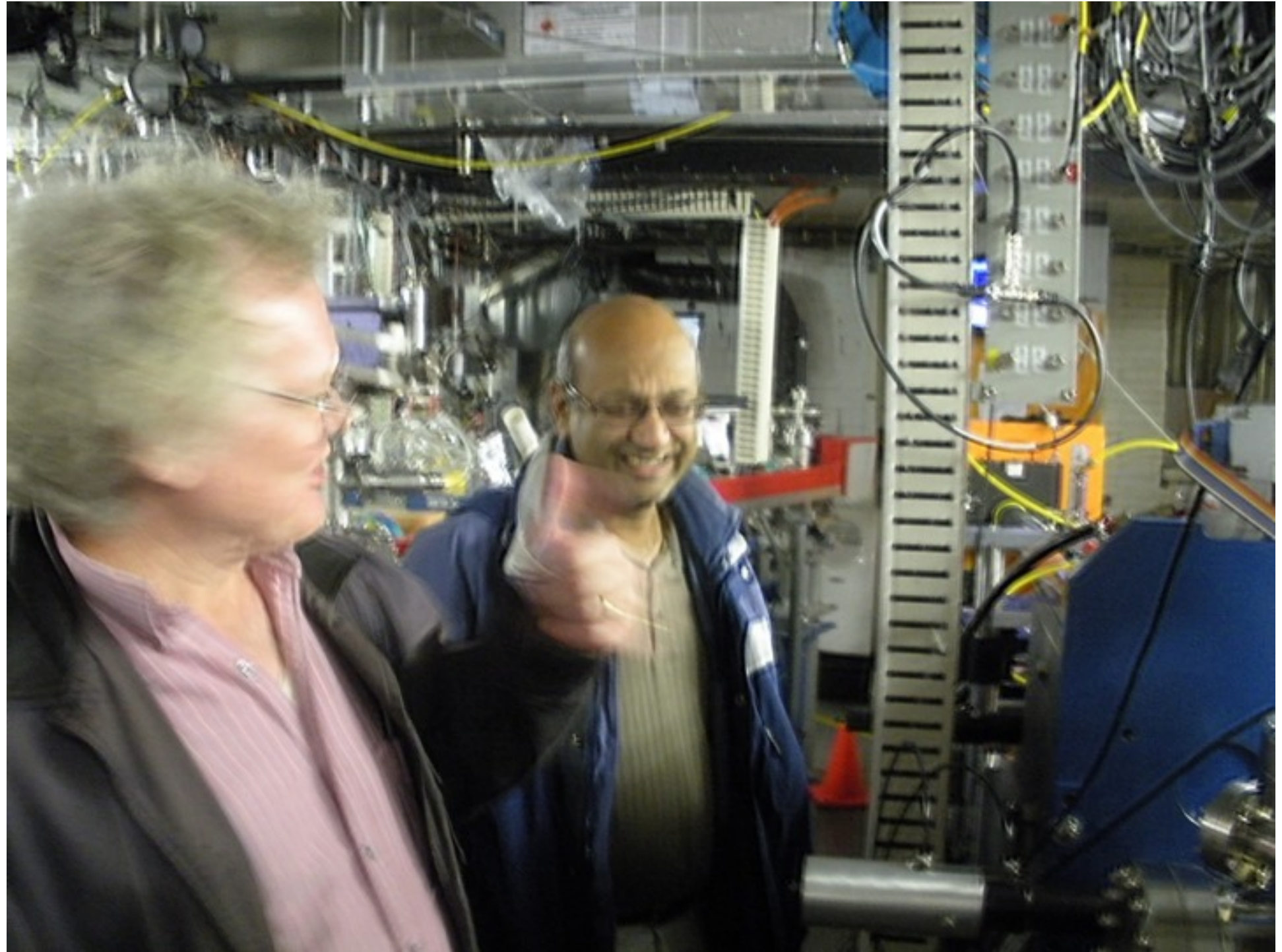
Rutherford Scattering



- ZnS is very hard to see @ 1 Hz
- $\text{Cosec}(\theta/2)^4$ is a very rapid slope
- Rutherford saw departure from this
- Hofstadter showed that due to nuclear size
- H's experiments at ~ 100 MeV
- Form factor correction is huge $\sim *100$
- we are using this to make custom beam

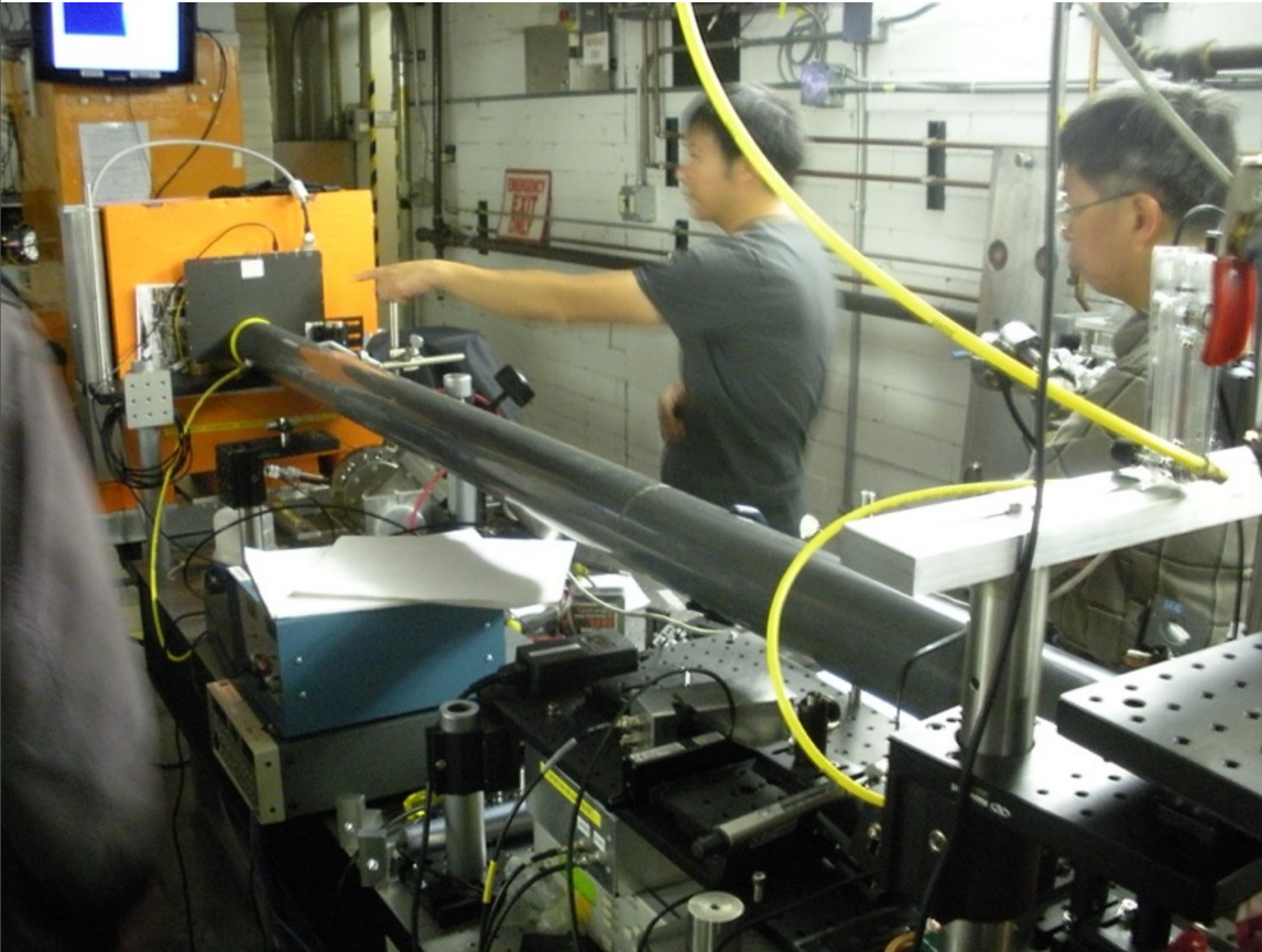
an 80 MeV electron accelerator

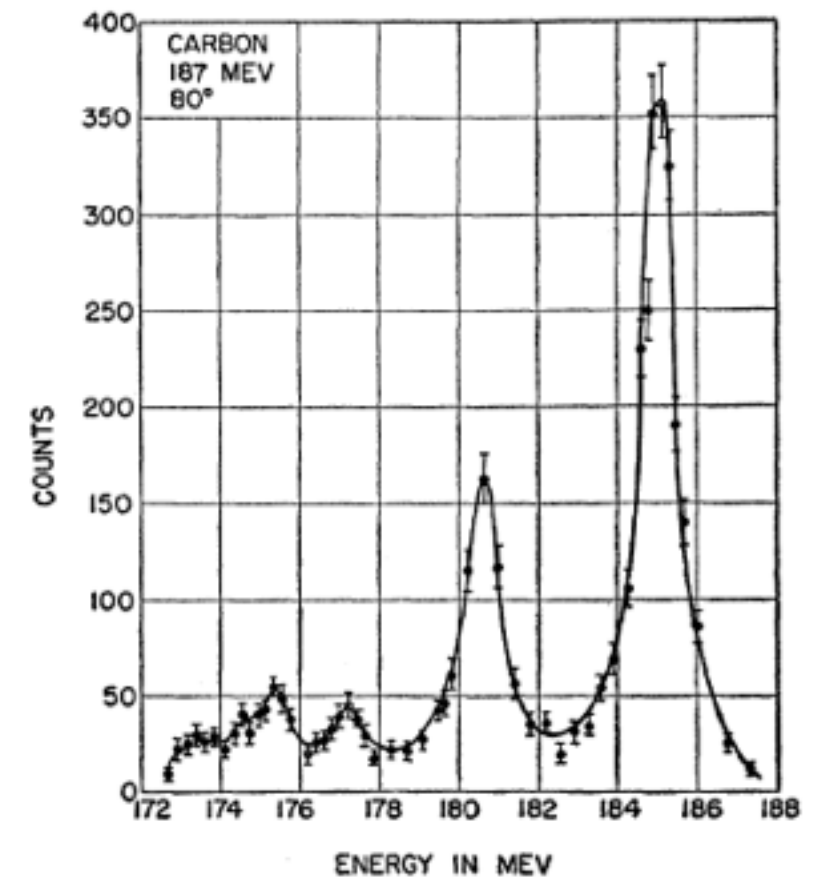
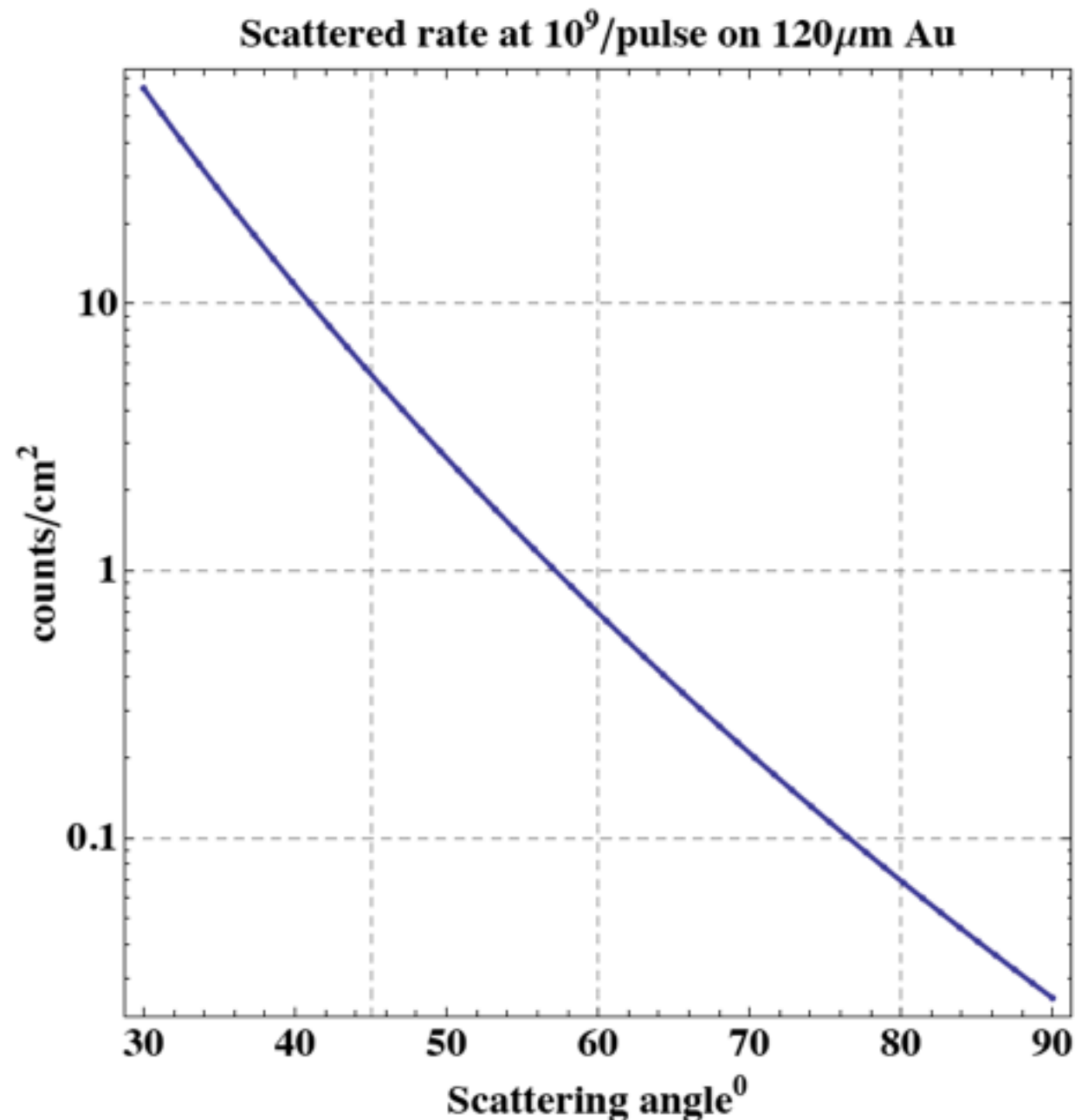
Kirk and Milind
between
beams 1 & 2



T. Tsang, M. Chiu, M. Diwan, S. White, G. Atoian, K. McDonald, K. Goulianos, D. Acker

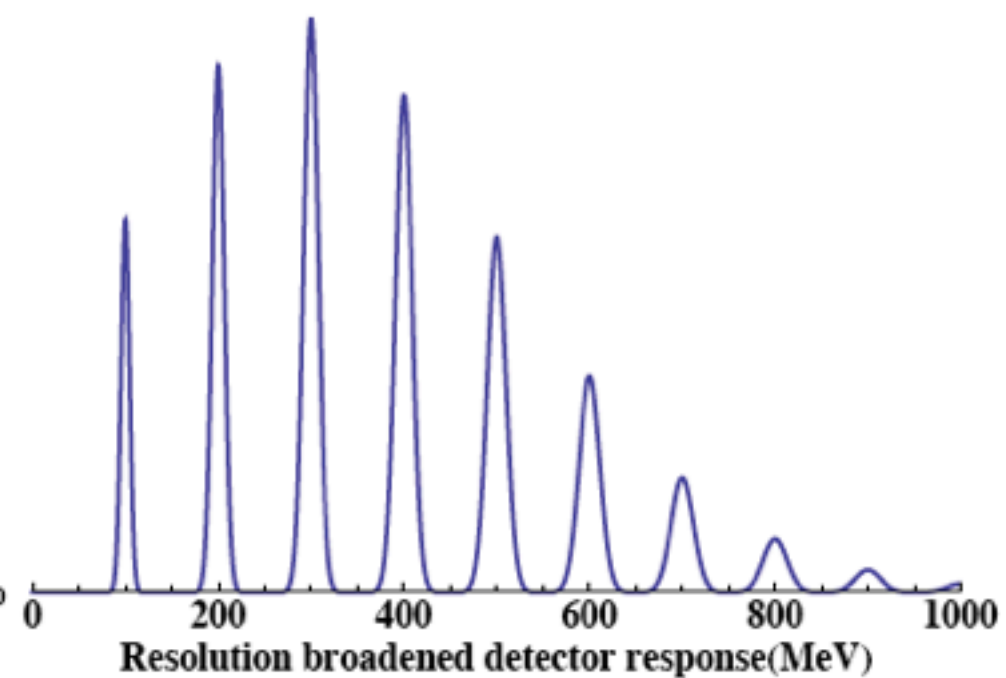
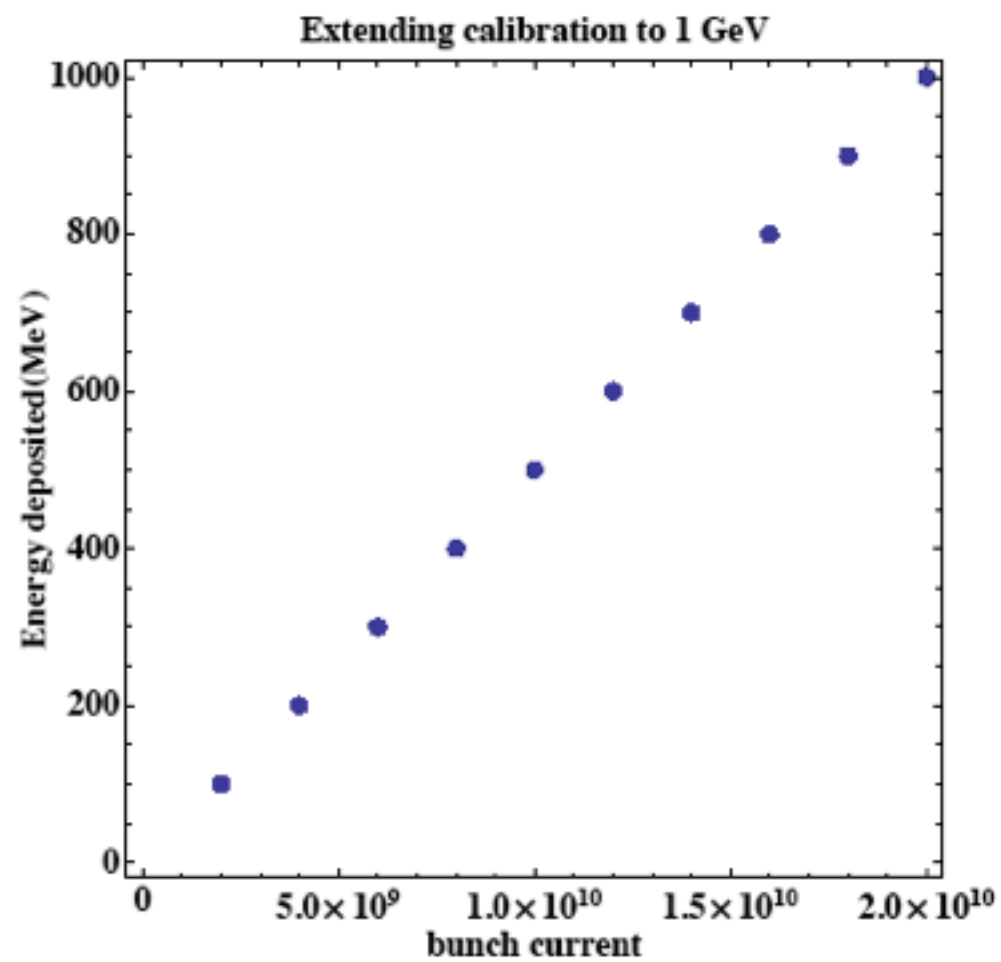
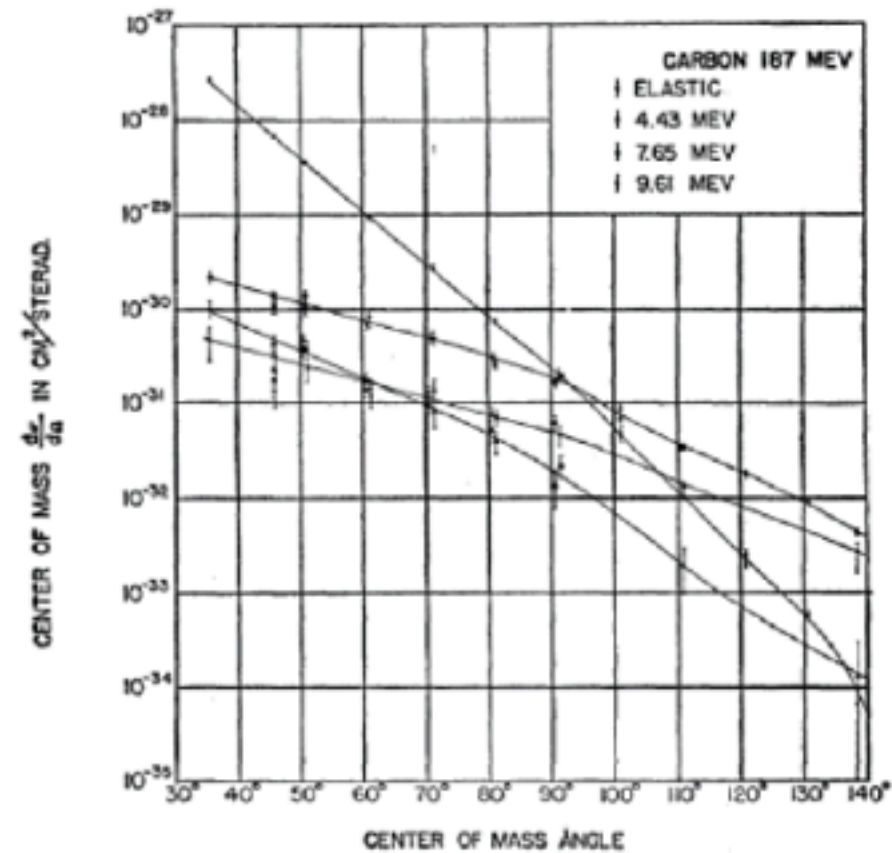
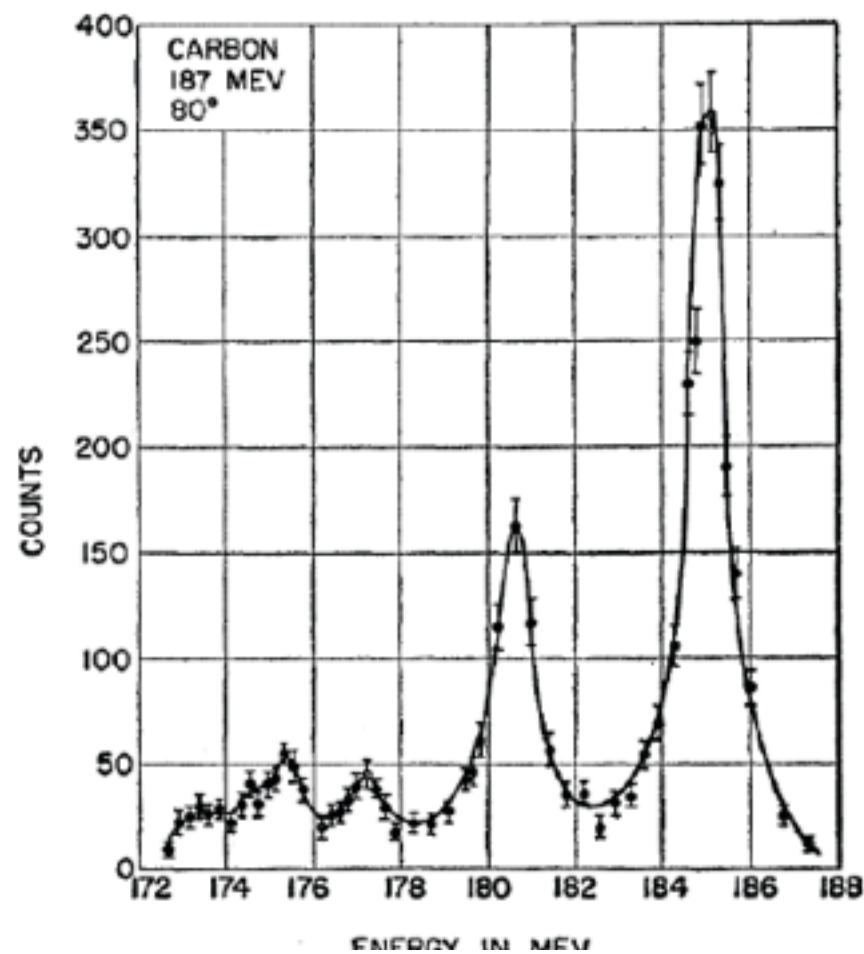
Applications: RHIC upgrades, electron-Ion Collider, SuperBelle, ATLAS- AFP





If you like inelastic peaks
you can tune them with
angle and Target choice.

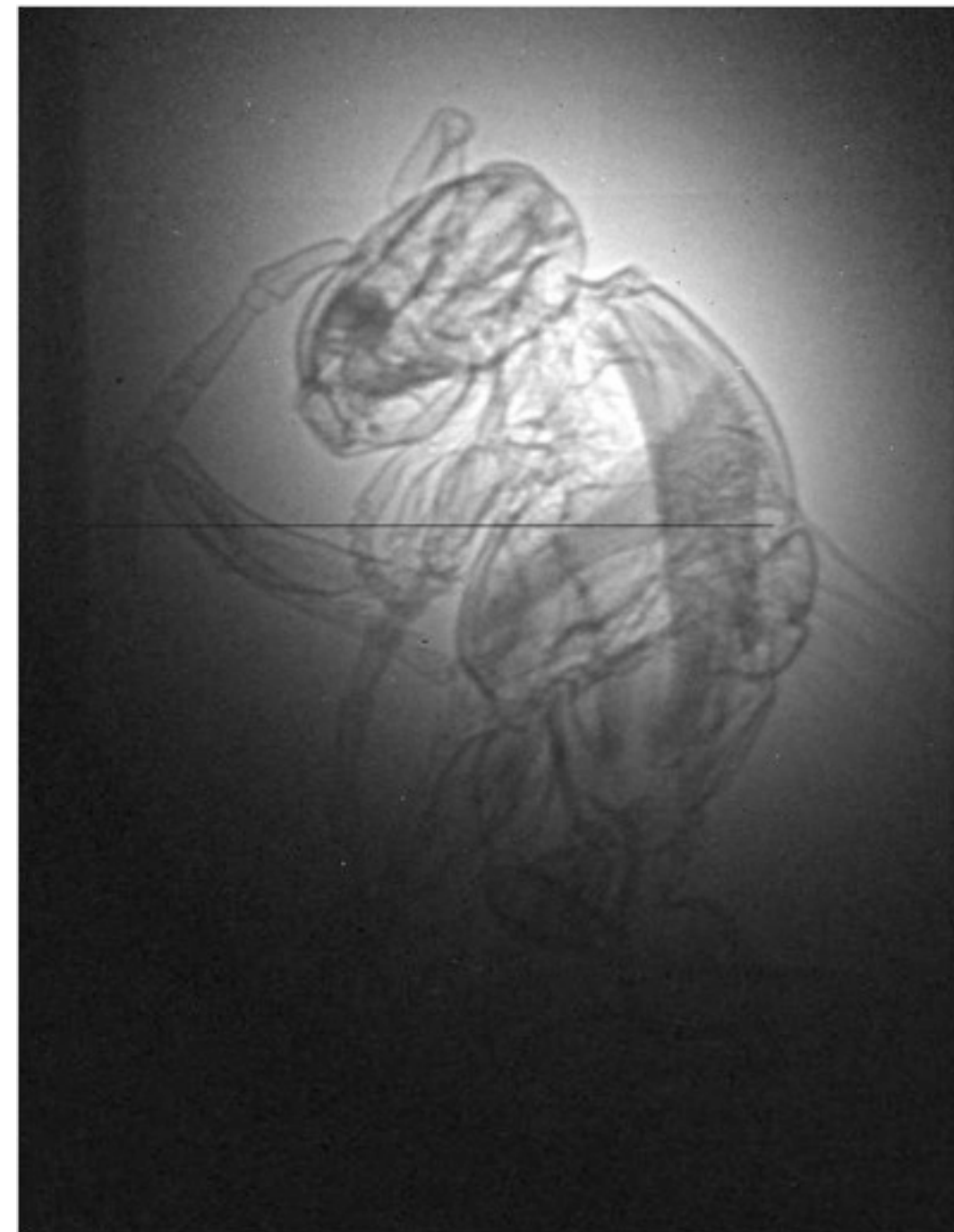
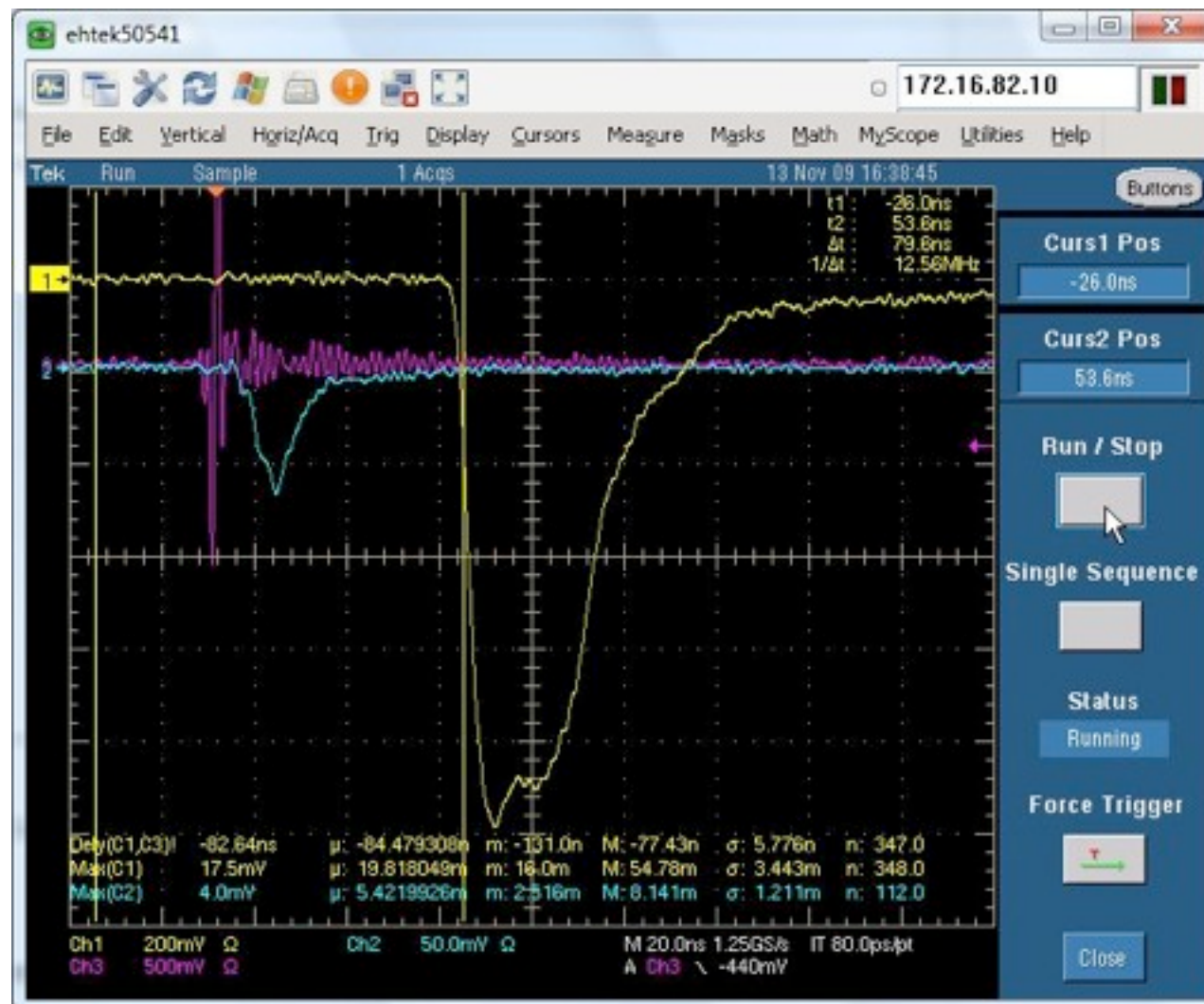
Hofstadter data were at ~80 MeV so easy to
check these calculations



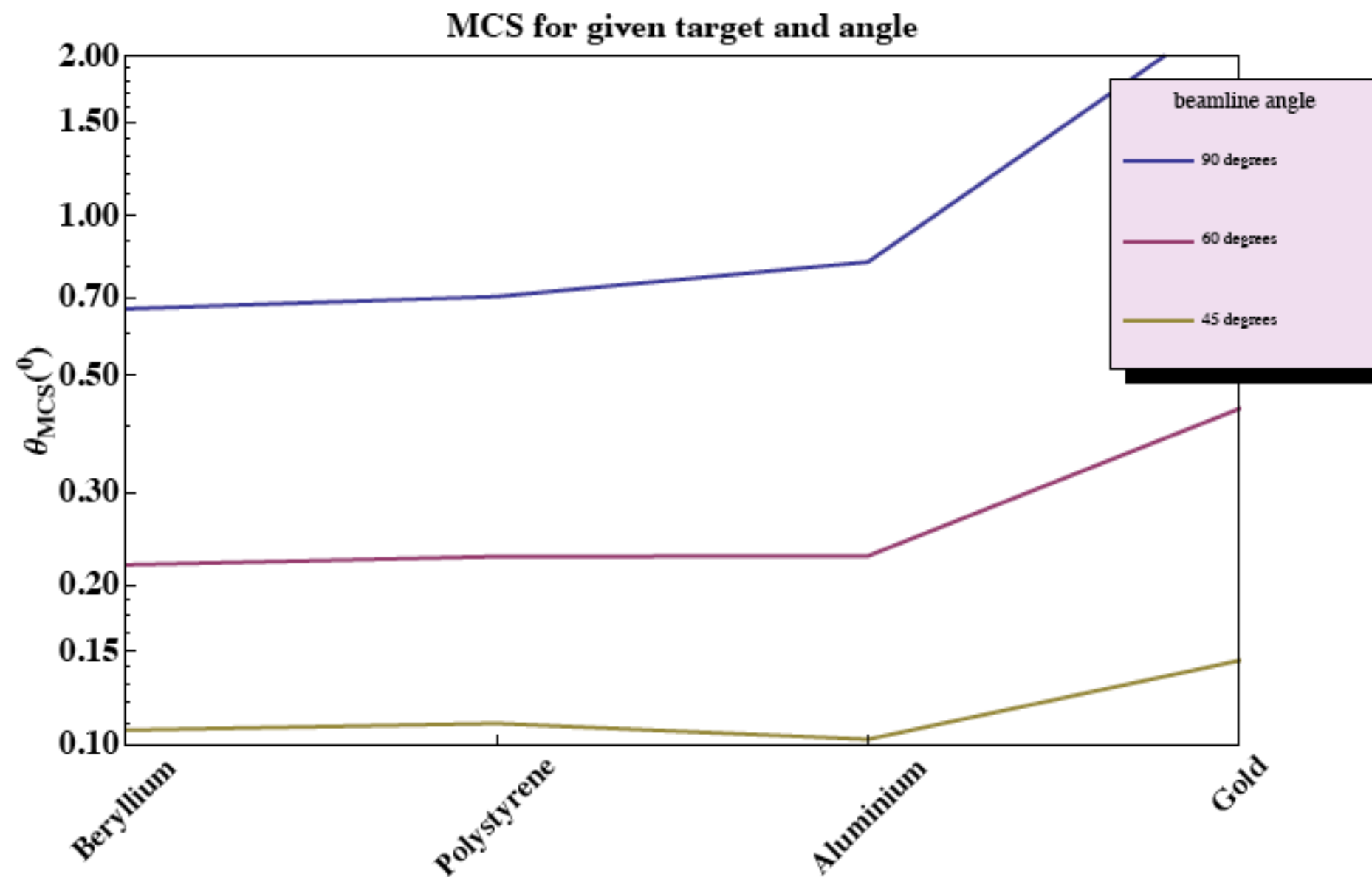
Background Test

direct e-hole pair measurement
with large active volume APD(blue)
In this case with large controlled
losses.

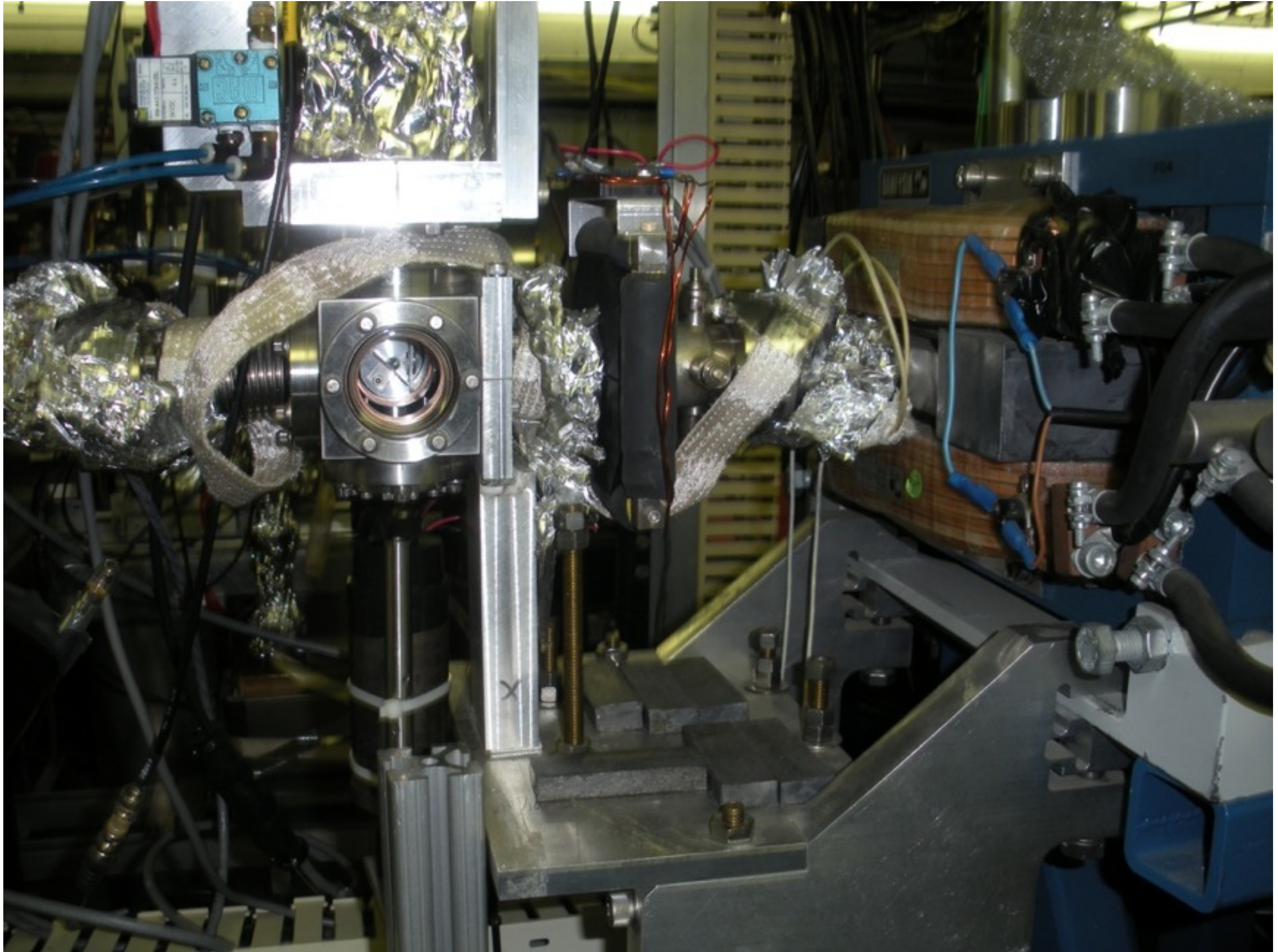
visual- from “the bee”



little dependence of emittance blowup on target type in spite of FF



the beamline



Custom made turn-key accelerator

Item	Value
RF operating frequency	2856 MHz
RF pulse flat-top duration	3 μ s
Max. RF input power	10 MW
Max. accelerating gradient	100 MV/m
Max. beam energy at gun output	4.5 MeV
Bunch charge	0.1-1 nC
Repetition rate	10 Hz
RF operating frequency	2856 MHz
RF pulse flat-top duration	3 μ s
Max. RF input power	15 MW
Max. accelerating gradient	20 MV/m
Max. energy gain per section	60 MeV
Repetition rate	10 Hz

The approximate breakdown of the total cost is as follows:

- Photoinjector gun system: \$440,000
- Photocathode drive laser system: \$481,000
- 100 MeV linear accelerator system: \$628,000
- RF power system: \$1,244,000
- Installation and commissioning support: \$129,000

Assembled Components

Table 5: rough Costs

Component costs	
TiSapphire Laser (ATF quote)	400k
Photoinjector (AES, Radia Beam)	350k
2 Klystrons	250k
2 Modulators	500k
2 Sections	300k
Low level RF, etc.	200k
Supports, etc.	100k
Total	2.1M USD

Installation/ Operating costs could be significant

- construction@ 1 RF/Laser engineer
- 1/2 year engineer for safety review
- 1-2 staff depending on operating model

Turn-key system could come with key training

Beam Transport

- Our design gives 0.1-0.7 degree MCS angle in outgoing beam.
 - original idea was to have no emittance impact and allow multiple beam ports.
 - now exploring optics after 1st target.
 - are multiple ports needed or practical?
- In the secondary beam we designed for 1 or 0.5 degree acceptance. To transport beam deep into detector need additional optics.
 - 0.5m triplet seems practical. basically point to parallel design
 - source is ~1mm spot and no momentum spread so we feel transport over many meters possible.